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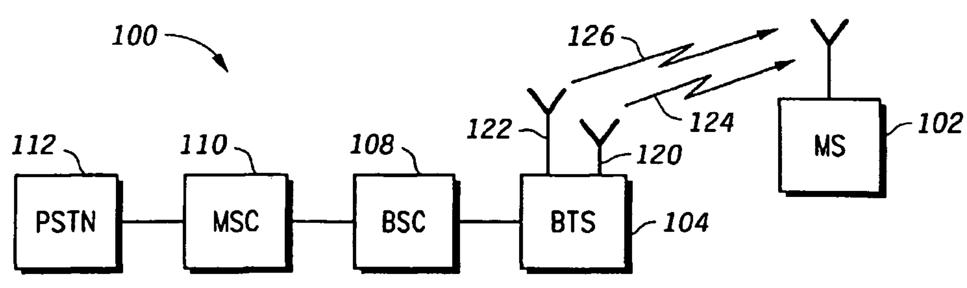
(54) Title: TRANSMISSION DIVERSITY IN A CELLULAR RADIO COMMUNICATION SYSTEM



(57) Abstract: An open-loop diversity method for a time division multiple access cellular radio communicatio system (100), comprising the steps of: providing a plurality of busts (310, 320) of data, each burst of data comprising a same information content as the other bursts of data, such that the busts of data can be distinguished from each other when received; substantially simultaneously transmitting the bursts of data from respective different antennas (120, 122); receiving the bursts of data from the different antennas; analysing the received burst of data; and retieving the information content from the distinguished busts of data. The cellular communication system thus implements provision, transmission, reception and processing of substantially simultaneous diversity bursts. In a preferred embodiment, training sequences (316, 326) are modified to enable data from different antennas to be distinguished.

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TRANSMISSION DIVERSITY IN A CELLULAR RADIO COMMUNICATION SYSTEM

Field of the Invention

This invention relates to transmission and reception in time division multiplexed access cellular radio communication systems. The invention is applicable to, but not limited to, Global System for Mobile Communications (GSM) and Enhanced Data Rate for Global Evaluation (EDGE) cellular radio communication systems.

Background of the Invention

In the field of telecommunications, it is generally known that transmission diversity improves the likelihood of given information content or data being received satisfactorily. In the particular field of time division multiplexed access (TDMA) cellular radio communication systems it is known that it is possible to use delayed diversity transmission, or antenna hop from burst to burst. These schemes can provide some gain in carrier to noise (C/N) levels, and also some gain in carrier to interference (C/I) levels.

However, these approaches have a disadvantage that delayed diversity uses a limited equaliser window of the system, e.g. GSM, receiver. Furthermore, it is only useful if the physical channel exhibits minimum channel

delay spread. For larger delay spreads the gain is small, and there is a chance that the equaliser will no longer be able to cope with the overall delay profile presented to the handset receiver. Even when the channel exhibits small delay spread, it is possible that some signal cancellation takes place.

Antenna hopping, on the other hand, only delivers useful gains if the receiving communication unit, e.g. a mobile station such as a mobile telephone, is stationary, which implicitly limits the usefulness of the method.

Many known diversity schemes employ feedback from a receiving unit to the transmitting unit. This requires increased processing levels and feedback channels, using up valuable communication resource. A contrasting possibility is a diversity scheme in which no feedback takes place, which is known as open-loop.

Thus, conventionally it is perceived that transmission diversity schemes are not suited for time division cellular radio communication systems.

It would therefore be desirable to provide a form of transmission diversity more suitable for TDMA cellular radio communication systems, thus enabling benefits of diversity to be achieved whilst alleviating the above-mentioned disadvantages of conventional diversity schemes. Furthermore, an open-loop scheme would advantageously reduce usage of communication resource.

Statement of Invention

In a first aspect, the present invention provides an open-loop diversity method for a time division multiplexed access cellular radio communication system, as claimed in claim 1.

In a second aspect, the present invention provides a method of transmitting with open-loop diversity in a time division multiplexed access cellular radio communication system, as claimed in claim 16.

In a third aspect, the present invention provides a method of receiving an open-loop diversity transmission in a time division multiplexed access cellular radio communication system, as claimed in claim 23.

In a fourth aspect, the present invention provides a storage medium storing processor-implementable instructions, as claimed in claim 33.

In a fifth aspect, the present invention provides an apparatus, as claimed in claim 34.

In a sixth aspect, the present invention provides a communication unit, as claimed in claim 35.

Further aspects are as claimed in the dependent claims.

In essence, according to the present invention, diversity is achieved by performing transmission (at least substantially) simultaneously (e.g. within the timing control of a single timeslot of the TDMA scheme) from multiple antennas to a receiving communication unit such as a mobile terminal. This is open-loop diversity, i.e. is performed without the need to provide a feedback route, for optimising signal levels or phases in the different antennas, from the receiving communication unit to the transmitting unit. Therefore the present invention does not need feedback channels to achieve diversity gain. However, unlike delayed transmit diversity, the gain is not highly sensitive to the characteristics of the radio channel. Generally, a diversity procedure more attuned to a TDMA cellular radio communication system is provided.

In a preferred embodiment, a cellular communication system implements provision, transmission, reception and processing of substantially simultaneous diversity bursts.

In a preferred embodiment, training sequences are modified to enable data from different antennas to be distinguished.

Brief Description of the Drawings

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic illustration of part of a cellular radio communication system;

FIG. 2 is an illustration in schematic block diagram form of certain parts of a communication unit;

FIG. 3 illustrates a decoding process;

FIGS. 4A and 4B schematically illustrate processing functions employed by the communication unit of FIG. 2; and

FIG. 5 is a schematic illustration of part of a cellular radio communication system.

Description of Preferred Embodiments

FIG. 1 is a schematic illustration of part of a cellular radio communication system 100 in which a first embodiment may be implemented. The system 100 is a GSM system modified to perform the diversity method of this embodiment.

A communication unit, which may be described as a receiving communication unit in the context of this embodiment, and in this example is a mobile station (MS) 102 (e.g. a mobile telephone), receives communication service from a base transceiver station (BTS) 104. The BTS 104 also constitutes a communication unit, and may be described as a transmitting communication unit in the context of this embodiment. The BTS 104 is coupled to a base station controller (BSC) 108. The BSC 108 is coupled to a mobile services switching centre (MSC) 110, which is itself coupled to a public switched telephone network (PSTN) 112.

The BTS 104 contains a plurality of antennas, of which two are shown, namely antennas 120 and 122. When this embodiment is implemented, both antenna 120 and antenna 122 form respective radio links 124 and 126 with the MS 102, and transmit TDMA bursts containing a same information content simultaneously (i.e. substantially simultaneously, preferably in the same timeslots) to the MS 102.

In this embodiment, the BTS 104 and the MS 102 have been adapted, to offer, and provide for, open loop transmission diversity, as will be described in more detail below. More particularly, in this embodiment the BTS 104 has been adapted to implement the present invention in a transmitting mode of operation, and the communication unit 102 has been adapted to implement the present invention in a receiving mode of operation.

The adaptations may be implemented in the respective communications units in any suitable manner. For example, new apparatus may be added to a conventional communications unit, or alternatively existing parts of a conventional communications unit may be adapted, for example by reprogramming of one or more processors therein. As such the required adaptation may be implemented in the form of processor-implementable instructions stored on a storage medium, such as a floppy disk, hard disk, PROM, RAM or any combination of these or other storage media.

It is also within the contemplation of the invention that such adaptation of transmission characteristics may alternatively be controlled, implemented in full or implemented in part by adapting any other suitable part of the communications system 100. For example, conventional BTSs, comprising plural antennas, but in which the antennas conventionally only transmit different information content from each other, may be controlled by a modified BSC 108 such as to implement the present embodiment.

In the case of other system or network infrastructures, implementation may be at any appropriate node such as any other appropriate type of base station, base station controller etc. Alternatively the various steps involved in determining and carrying out such adaptation (as will be described in more detail below) can be carried out by various components distributed at different locations or entities within any suitable network or system.

With respect to aspects relevant to understanding this embodiment, the MS 102 and the BTS 104 each constitute a communications unit. Details of MS 102 will now be described with reference to FIG. 2, which is an illustration in schematic block diagram form of certain parts of MS 102 that are useful for understanding the present embodiment.

MS 102 contains an antenna 202 coupled to a duplex filter or circulator 204 that provides isolation between receive and transmit chains within the MS 102.

The receiver chain, as known in the art, includes scanning receiver front-end circuitry 206 (effectively providing reception, filtering and intermediate or base-band frequency conversion). The scanning front-end circuit is serially coupled to a signal processing function 208.

An output from the signal processing function is provided to output 210. The output 210 includes a loudspeaker for audio output, a display and a data services output. (In the case of BTS 104, the corresponding output comprises interface means for communicating with the BSC 108.)

The receiver chain also includes received signal strength indicator (RSSI) circuitry 212, which in turn is coupled to a controller 214 that operates to maintain overall control of the different functions and modules of the MS 102. The controller 214 is also coupled to the scanning

receiver front-end circuitry 206 and the signal processing function 208 (generally realised by a digital signal processor, i.e. DSP).

The controller 214 includes a memory 216 that stores operating regimes, including those of interest with respect to this invention such as analysing received bursts of data to distinguish between the different bursts of data, and retrieving information content from the distinguished bursts of data, as will be described in more detail below. A timer 218 is typically coupled to the controller 214 to control the timing of operations (transmission or reception of time-dependent signals) within the MS 102.

As regards the transmit chain, this includes an input 220. Input 220 includes a microphone for a user's voice input, and a keyboard. (In the case of BTS 104, input 220 comprises interface means for receiving communication from BSC 108.) The input device is coupled in series through transmitter/modulation circuitry 222 and a power amplifier 224 to the antenna 202. The transmitter/modulation circuitry 222 and the power amplifier 224 are operationally responsive to the controller 214.

The above description of MS 102 applies equally to BTS 104, except that BTS 104 has plural antennas.

The various components within MS 102 and BTS 104 are realised in this embodiment in integrated component form.

Of course, in other embodiments, they may be realised in discrete form, or a mixture of integrated components and discrete components, or indeed any other suitable form. Further, in this embodiment the controller 214 including memory 216 is implemented as a programmable processor, but in other embodiments can comprise dedicated circuitry or any other suitable form.

It is noted that corresponding features to those described above with respect to communication unit 110 are also found in conventional communication units (i.e. base stations and MSs). However, in this embodiment MS 102 and BTS 104 differ over conventional communication units by virtue that the controller 214, including memory 216, and where appropriate, the signal processing function 208 and the transmitter/modulation circuitry 222 is adapted with respect to provision (BTS 104), transmission (BTS 104), reception (MS 102) and processing (MS 102) of substantially simultaneous diversity bursts, as will be described in more detail below.

Details of the processing carried in this embodiment by the above-described components will now be described. In this embodiment, the following problems are solved:

(i) Independent channel estimation of the multiple signal paths; and

(ii) Decoding of signals received from multiple antennas.

In order to solve problem (i), we note that both in a gaussian minimum shift keyed (GMSK) system, such as that used by GSM and 8-phase shift keyed (8-PSK) mode of operation, the training sequence used is the same (the training sequence is a sequence of modulating bits employed to facilitate timing recovery and channel equalisation in the receiver). However a phase rotation is applied which can be used to distinguish the two different modes. This means that a phase shift is applied to each subsequent symbol, the shift increasing with each new data symbol. For GMSK the rotation is $\exp(j\ n\ \pi / 2)$ whilst for 8-PSK the rotation is $\exp(j\ n\ \pi / 8)$, where n is the symbol number. In GSM and EGPRS, either one or the other training sequences are included in every normal data burst.

The two sequences are theoretically orthogonal over a 16-symbol span, since essentially they are complex sinusoids modulated by the same pseudo-random sequence with a good auto correction. They will also remain orthogonal in spite of delays since the orthogonality between the complex sinusoids is maintained even with a phase shift. Hence it is possible to detect the mode by correlating with the two possible transmitted sequences. Mode detection errors will be caused by high relative noise levels or excessive multipath.

In this embodiment, this concept is generalised by transmitting simultaneously (i.e. not selectively) from multiple antennas with the same sequence and different shifts. In this case, the MS 102 analyses the received

training sequence but splits it into multiple copies using the knowledge that the phase rotations are different. In this way the MS 102 can identify the channels from the multiple base station antennas to the mobile antenna. Negative shifts can also be used.

Example 1: for 2-antenna in GMSK mode (i.e. normal GSM)
Use $\exp(j \; n \; \pi / 2)$ and $\exp(-j \; n \; \pi / 2)$

Example 2: for 2-antenna in 8-PSK mode
Use $\exp(j \; n \; \pi / 8)$ and $\exp(-j \; n \; \pi / 8)$

Example 3: for 4-antenna in 8-PSK mode
Use $\exp(j \; n \; \pi / 8)$, $\exp(-j \; n \; \pi / 8)$, $\exp(j \; n \; \pi / 4)$ and $\exp(-j \; n \; \pi / 4)$

The MS 102 has separate correlators 'tuned' into the orthogonal sequences, each one then obtains a channel estimate corresponding to the signal path from each antenna to the MS. It is noteworthy that as well as normal estimate corruption due to noise and multipath, some cross-correlation may also result in high multipath conditions. The sequences are orthogonal only when assuming circular repetition, and thus as multipath effects appear some cross-correlation will also appear due to the effects of the data symbols on either side of the sequence.

Note that there is no impact on the Power Amplifier (PA) required if only 2 antennas are used for GSM (the signal is still GMSK-like, therefore with a constant envelope).

If more antennas are used, the resulting rotation imposes larger phase shifts from symbol to symbol resulting in a

The data contained in sub-blocks A and B is repeated in the second burst type 320, transmitted from the second antenna 122, but with several differences:

(i) For the second antenna 122, the two sub-blocks are reversed so that there is no systematic cancellation of the data.

(ii) In the second antenna, one of the sub-blocks is inverted in amplitude. This is useful for the data manipulation detailed below.

(iii) In the second antenna, the order of the data symbols inside the two sub-blocks is reversed. This is because normal demodulation is carried out from the training sequence outwards, and therefore the lowest order symbols are the closest to the TS.

This is indicated by the prime notation. In processing, the symbols are reversed anyway so this can be ignored.

Thus, overall, the burst 320 from the second antenna 122 comprises a first sub-block B′ (indicated by reference numeral 322), a training sequence TS2 (indicated by reference numeral 326) and a second sub-block "inverted A′" (represented by the character "A′" with a bar thereover) (indicated by reference numeral 324).

Now consider that the channel gain is h1 for the first antenna link and h2 for the second. Hence, the signal S1

received in the first sub-block, and the signal S2 received in the second sub-block, are respectively:

$$S1 = h1 . A + h2 . B$$

$$S2 = -h2 . A + h1 . B$$

Since we have knowledge of the channel gains from the channel estimation process, we can now apply a combiner between the two sub-bursts. For example:

$$h_1^* S_1 - h_2^* S_2 = |h_1|^2 A + |h_2|^2 A + [h_1^* h_2 - h_1 h_2^*]B$$

$$h_2^* S_1 + h_1^* S_2 = |h_2|^2 B + |h_1|^2 B + [h_2^* h_1 - h_2 h_1^*]A$$

It should be clear that in the first expression, the coefficients multiplying A are purely real and those multiplying B are purely imaginary (the reverse is true for the second sequence). Hence since the symbols in A and B are alternately real and imaginary (but both of the same type for each symbol), then taking alternately the real and the imaginary part of each of the two sums yields the data segments A and B.

So far it has been assumed that the channel exhibits a single path and in general a single channel coefficient, and also that the data symbols are alternately real and imaginary, as in the GMSK transmission used in GSM and

GPRS. Here there is in fact a multipath, and in this embodiment this is accounted for by replacing the multiplying coefficient with a matched filter, as will now be described with reference to FIGS. 4A and 4B, which schematically illustrates processing functions employed by the MS 102 in this embodiment.

FIG. 4A shows the overall signal S1 from the respective first sub-blocks 312 and 322 being passed through a matched filter 410 that is matched to channel 1, and the overall signal S2 from the respective second sub-blocks 314 and 324 being passed through a further matched filter 415 which is matched to channel 2. The outputs from the two matched filters are added in a combiner 420 and then forwarded to an equaliser 425, which equalises the outputs. FIG. 4B shows the same arrangement, except that one of the inputs to the combiner 420 is inverted.

In this embodiment the equaliser consists of a maximum likelihood sequence estimator, using the knowledge of the two channels. It is clear that in the general case there is considerable interference from sequence A into B and vice-versa due to the channel dispersion and the matched filter. If either channel is much larger than the other, then there is no issue since this interference will be small. However, even in this case there may be significant cross-sequence interference if the symbols are not alternately real and imaginary as in some modes in EDGE.

In this embodiment either of two ways may be used to carry out the 'unwrapping' of this interference:

(i) Effectively a single maximum likelihood estimator operates simultaneously across the outputs of the two combiners. This means that, for GMSK transmission as in GSM, there are effectively four states for each 'symbol' i.e. A=±1 and B=±1. Assuming a channel memory of five symbols, the equaliser will have 4^4 (i.e. 256) states. This compares with a sixteen-state equaliser for each of the two blocks separately, and the two equalisers 425 in FIGS. 4A and 4B may be considered to be a single processing entity. (This simultaneous method may be summarised as simultaneous estimation of the two sequences.)

(ii) Alternatively an iterative process is applied whereby the initial decisions from running sixteen-state equalisers on each of the sequences is used to feedback into another pass through the estimator (but this time cancelling the estimated contributions from the other sequence) (this iterative process may be summarised as sequential interference cancellation of the two sequences).

Whichever technique is used, the receiver now benefits from the channel gains from the two antennas, thereby reducing fading (diversity gain). Although in this embodiment two antennas are used to provide diversity, in other embodiments a larger number of antennas may be

used. In this case the scheme is extended to more antennas by designing other burst mappings.

An optional characteristic of these schemes is that they may also be applied to macro-diversity (soft handover) operation. Frame synchronisation would be imposed between neighbouring BTSs for this.

In the above embodiment, the plural antennas are located at the same BTS 104. In an alternative embodiment, the different antennas may each be at different respective BTSs. FIG. 5 shows the system 100 of FIG. 1 with such an arrangement. In FIG. 5, all the items are the same as in FIG. 1 (and indicated by the same reference numerals), except that in this embodiment BTS 104 is replaced by BTS 105 and BTS 106, each carrying one of the antennas 120, 122.

In the above embodiment, MS 102 is a mobile telephone, but the receiving communication unit may include or consist of any other appropriate form of radio receiving apparatus, for example personal computers with radio modems, electronic organisers, video and/or audio players, etc.

The present invention finds particular application in wireless communication systems such as UMTS or EDGE systems. However, the inventive concepts contained herein are equally applicable to alternative wireless communications systems. Whilst the specific, and preferred, implementations of the present invention are

described above, it is clear that variations and modifications of such inventive concepts could be readily applied by one skilled in the art.

It will be understood that the transmit diversity embodiments using multiple burst formats for GSM and EDGE described above provide the following advantages:

(i) the system will not require feedback;

(ii) the receiver benefits from the channel gains from the two antennas, thereby reducing fading (diversity gain); and

(iii) the scheme may be readily extended to more antennas by designing other burst mappings.

Claims

1. An open-loop diversity method for a time division multiple access cellular radio communication system, comprising the steps of:

providing a plurality of bursts of data, each burst of data comprising a same information content as the other bursts of data, such that the bursts of data can be distinguished from each other when received;

substantially simultaneously transmitting the bursts of data from respective different antennas;

receiving the bursts of data from the different antennas;

analysing the received bursts of data to distinguish between the different bursts of data; and

retrieving the information content from the distinguished bursts of data.

2. A method according to claim 1, wherein the step of providing the plurality of bursts of data such that the bursts of data can be distinguished from each other when received comprises the step of:

modifying training sequences of the bursts of data.

3. A method according to claim 2, wherein the step of modifying the training sequences comprises the step of:

providing the training sequence of each burst of data with a different phase shift.

4. A method according to any preceding claim, further comprising the steps of:

dividing the information content into a plurality of sub-blocks; and

using a different order of the sub-blocks for each respective burst of data.

5. A method according to claim 4, further comprising the step of:

inverting one or more of the sub-blocks in one or more of the bursts of data.

6. A method according to claim 5, further comprising the step of:

reversing the order of data symbols in one or more of the sub-blocks.

7. A method according to any of claims 4 to 6, wherein the number of sub-blocks in the plurality of sub-blocks is two.

8. A method according to any preceding claim, wherein the step of analysing the received bursts of data to distinguish between the different bursts of data comprises the step of:

analysing the training sequences.

9. A method according to claim 8, wherein the step of analysing the training sequences comprises the step of:

analysing the phases of the training sequences.

10. A method according to claim 9, wherein the step of analysing the phases comprises the step of

using separate correlators to identify specific phases.

11. A method according to claim 4 or any of claims 8 to 10 when dependent from claim 4, wherein the step of retrieving the information content from the distinguished bursts of data comprises the step of:

combining the plural sub-blocks.

12. A method according to any preceding claim, wherein each burst of data provides a corresponding channel, and the step of retrieving the information content from the distinguished bursts of data comprises the step of:

using a plurality of matched filters, the plurality of matched filters comprising a respective matched filter for each said channel.

13. A method according to claim 12 when dependent from claim 11, wherein outputs from the matched filters are combined and forwarded to an equaliser, and the equaliser recovers the information in the respective sub-blocks.

14. A method according to claim 13, wherein the equaliser recovers the information in the respective sub-blocks by means of simultaneous estimation of sequences from the matched filter outputs.

15. A method according to claim 13, wherein the equaliser recovers the information in the respective sub-blocks by means of sequential interference cancellation of sequences from the matched filter outputs.

16. A method of transmitting with ~~open loop~~ diversity in a time division multiple access cellular radio communication system, comprising the steps of:

providing a plurality of bursts of data, each burst of data comprising a same information content as the other bursts of data, such that the bursts of data can be distinguished from each other when received; and

substantially simultaneously transmitting the bursts of data from respective different antennas.

17. A method according to claim 16, wherein the step of providing the plurality of bursts of data such that the bursts of data can be distinguished from each other when received comprises the step of:

modifying training sequences of the bursts of data.

18. A method according to claim 17, wherein the step of modifying the training sequences comprises the step of

providing the training sequence of each burst of data with a different phase shift.

19. A method according to claim 16 or 17, further comprising the steps of:

dividing the information content into a plurality of sub-blocks; and

using a different order of the sub-blocks for each respective burst of data.

20. A method according to claim 19, further comprising the step of:

inverting one or more of the sub-blocks in one or more of the bursts of data.

21. A method according to claim 20, further comprising the step of:

reversing the order of data symbols in one or more of the sub-blocks.

22. A method according to any of claims 19 to 22, wherein the number of sub-blocks in the plurality of sub-blocks is two.

23. A method of receiving an open-loop diversity transmission in a time division multiple access cellular radio communication system, comprising the steps of:

receiving a plurality of bursts of data from different antennas substantially simultaneously, wherein each burst of data comprises a same information content as the other bursts of data;

analysing the received bursts of data to distinguish between the different bursts of data; and

retrieving the information content from the distinguished bursts of data.

24. A method according to claim 23, wherein the step of analysing the received bursts of data to distinguish between the different bursts of data comprises the step of:

analysing modified training sequences of the bursts of data.

25. A method according to claim 24, wherein the step of analysing the training sequences comprises the step of:

analysing the phases of the training sequences.

26. A method according to claim 25, wherein the step of analysing the phases comprises the step of:

using separate correlators to identify specific phases.

27. A method according to any of claims 24 to 26, wherein in each burst of data the information content is divided into a plurality of sub-blocks; and the step of retrieving the information content from the distinguished bursts of data comprises the step of:

combining the plural sub-blocks.

28. A method according to any of claims 24 to 27, wherein each burst of data provides a corresponding channel, and the step of retrieving the information content from the distinguished bursts of data comprises the step of:

using a plurality of matched filters, the plurality of matched filters comprising a respective matched filter for each said channel.

29. A method according to claim 28 when dependent from claim 27, wherein outputs from the matched filters are combined and forwarded to an equaliser, and the equaliser recovers the information in the respective sub-blocks.

30. A method according to claim 29, wherein the equaliser recovers the information in the respective sub-blocks by means of simultaneous estimation of sequences from the matched filter outputs.

31. A method according to claim 29, wherein the equaliser recovers the information in the respective sub-blocks by means of sequential interference cancellation of sequences from the matched filter outputs.

32. A method according to any preceding claim, adapted for use in a GSM or EDGE cellular radio communication system.

33. A storage medium storing processor-implementable instructions for controlling one or more processors to carry out the method of any of claims 1 to 30.

34. Apparatus adapted to implement the method of any of claims 1 to 32.

35. A communication unit comprising apparatus according to claim 34.

36. A method substantially as hereinbefore described with reference to the accompanying drawings.

37. A communication unit substantially as hereinbefore described with reference to the accompanying drawings.

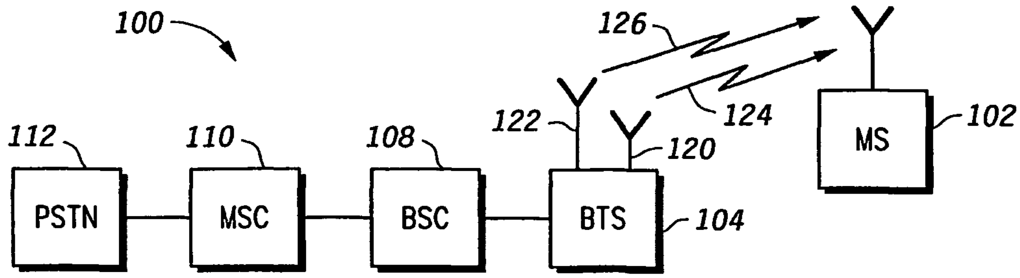

FIG.1

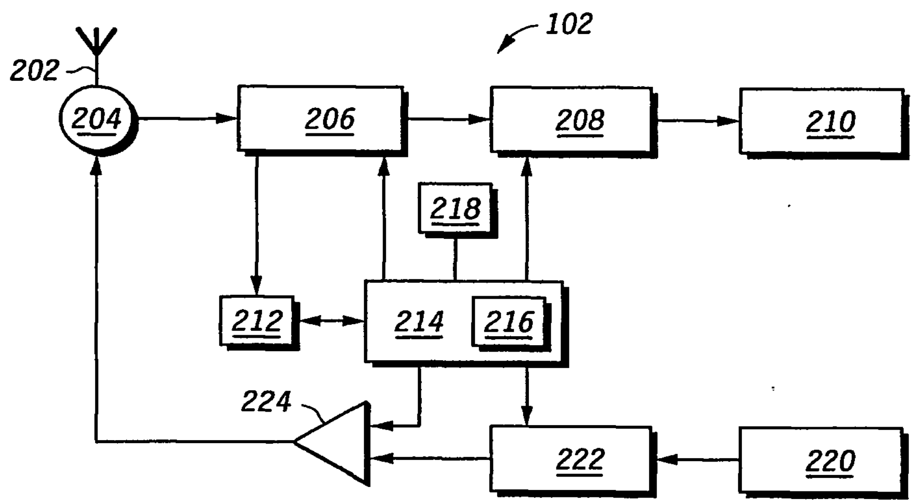

FIG.2

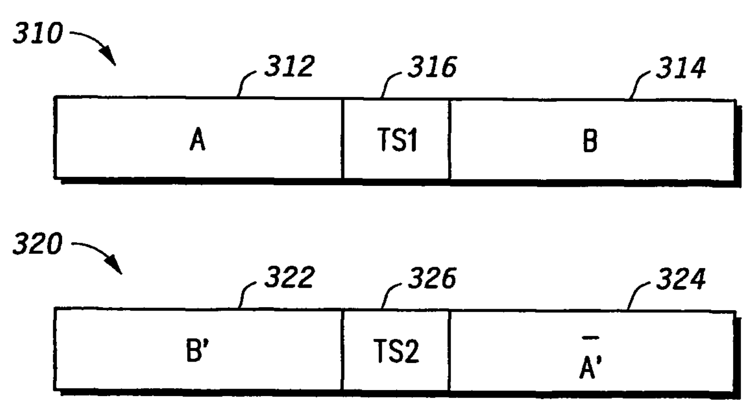

FIG.3

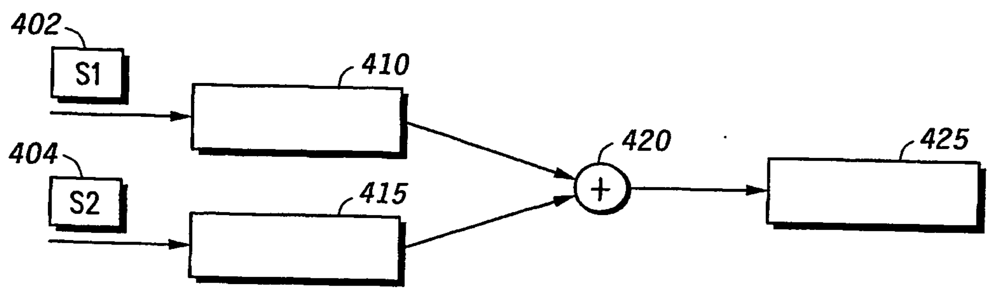

FIG.4A

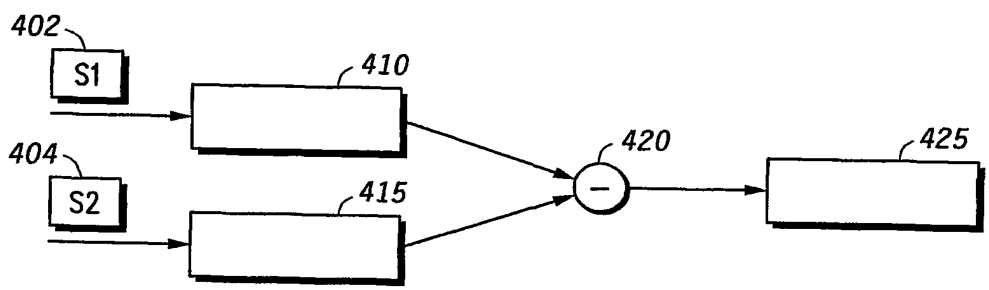

FIG.4B

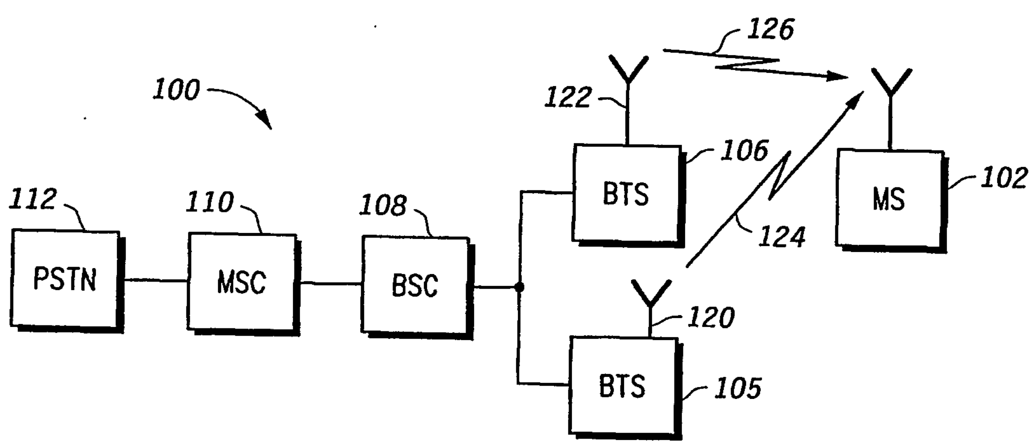

FIG.5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/06064

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, COMPENDEX, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 069 707 A (MOTOROLA INC) 17 January 2001 (2001-01-17) abstract figure 2 column 4, line 45 –column 4, line 52 column 5 –column 6 --- -/--	1,2,4-8, 16,17, 19-24, 33-37

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2002	20/11/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Cabañas Prieto, A.M.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/06064

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NAGUIB A F ET AL: "Space-time coded modulation for high data rate wireless communications" GLOBAL TELECOMMUNICATIONS CONFERENCE, 1997. GLOBECOM '97., IEEE PHOENIX, AZ, USA 3-8 NOV. 1997, NEW YORK, NY, USA,IEEE, US, 3 November 1997 (1997-11-03), pages 102-109, XP010254629 ISBN: 0-7803-4198-8 abstract page 104 page 105 figures 4-6	1,2,16, 17,23, 24,32-37
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X,P	EP 1 128 575 A (ERICSSON TELEFON AB L M) 29 August 2001 (2001-08-29) abstract	1,2,16, 17,23, 24,32-37
E	WO 02 49236 A (INTERDIGITAL TECH CORP) 20 June 2002 (2002-06-20) abstract; figures 1,2	1,2,16, 17,23,24
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 02/06064

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